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Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.
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AMERICAN-GROWN PAPRIKA PEPPER.[1]

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HISTORICAL INTRODUCTION.

Although the chain of evidence is not complete, it is probable that the forms of red peppers going under the name of "paprika," like other forms belonging to the genus Capsicum, came originally from the warmer part of the American continent. The name "paprika" seems to have been a local name used in Hungary and in the regions to the eastward for an elongated, medium-sized pepper distinguished by a deep-red color, rather thick, sweet flesh, and a very marked pungency.

From the evidence at hand it appears that the cultivation of this form of red pepper was carried on at a much earlier date than can be definitely associated with the name now so widely used. It is probable that the first European occurrence of paprika was in Spain or Portugal at an uncertain early date, perhaps not long after the discovery of America. The activity of the Spanish traders in the Mediterranean Sea and in the Orient probably led to the introduction of this, with other forms of the genus, into these regions. According to Augustin,[2] the development of pepper growing in Greece arose out of this commerce with the Iberian Peninsula. With Greece as an early starting point in southeastern Europe the cultivation and use of this type of pepper seems to have spread to adjacent countries, involving southern Russia and what is now Bulgaria. When the Mohammedan invaders were expelled from the plains of central and southern Hungary at the end of the seventeenth century these regions

[1] This bulletin sums up the results of an experiment having for its object the cultivation and marketing of red peppers of the type furnishing the Hungarian paprika of the spice market. The American demand for this condiment has increased rapidly during the last decade, until a large aggregate sum is now paid for this item for home consumption. This bulletin tells how to grow, cultivate, and cure the crop and discusses the economic as well as agricultural phases of the subject.—Wm. A. Taylor, *Chief of Bureau.*

[2] Augustin, Béla. Historisch-kritische und anatomisch-entwicklungsgeschichtliche Untersuchungen über den Paprika. Németbogsán, 1907, p. 16. Inaugural-Dissertation, Universität Bern.

were occupied by Germans from farther westward and by Greeks and Bulgarians coming from the East. It is supposed that the Bulgarians were especially concerned with the introduction of paprika culture, and its more recent development is said by Augustin to have been especially connected with the people of this race. This industry was carried on in the central and southern parts of Hungary, the peppers being used chiefly in a fresh condition. The curing of the ripe fruit for use as a powder is supposed to have been a secondary development, which in time centered especially around Szegedin, and in less measure about Kalocsa. These cities remain at present the chief centers of production for Hungarian paprika.

According to Augustin, the name "paprika" is of South Slavic origin and signifies "pungent," coming perhaps, with the culture of the plant, from the Bulgarians. It first occurs in the records in the eighteenth century and was used in the variant forms "piperka" and "peprika." This plant was known at much earlier dates as "Austrish pepper," "garden pepper," and less frequently as "Spanish pepper." It appears that the use of powdered paprika, especially among the lower classes, spread rapidly in Hungary, owing probably to its cheapness in comparison with black pepper. It has increased in general popularity, however, until it now largely displaces the oriental spice in those regions. The name "paprika" doubtless came to the United States with its users, who, through their importation of this article, seem to have introduced it to Americans at large. It has appealed in an increasing degree to the taste of the people, and its use has now extended far beyond the members of the races which brought it.

In addition to the original pungent, highly colored, and very aromatic paprika of Hungarian origin there has come another highly colored, aromatic, nonpungent, sweet pepper of Spanish origin, going frequently under the name of "Spanish paprika," or sometimes simply as "paprika." In Spain it goes under the name of "pimenton." It is probable that much of the popularity of this class of condiments has been due to an appreciation of the combination of mildness with high color seen in this latter article.

These two paprikas are derived from quite different forms of pepper, and it is necessary to bear in mind that the discussion in this paper pertains to the more pungent paprika of the Hungarian type.

LEGAL DEFINITION OF "PAPRIKA."

As has just been indicated, the name "paprika" is a class name used in actual commercial practice to designate at least two general types of product, with various grades in each. It is clear that in Hungary this name as a rule refers to that derived from the larger, sweeter, less pungent species of the genus Capsicum. It seems also

that the name rarely refers to the grades supposed to be prepared from the walls of the fruit, but rather to those which are made by grinding the whole pod, including the seeds and placentæ. The paprika occurring in American trade has reflected this character in response to the taste of the consumer and his varying ability to pay the price.

Under authority of the act of Congress of May 3, 1903, providing for the establishment of standards of purity for food products, a set of definitions of foods and drugs and their products was framed and issued as Circular 19 from the Office of the Secretary of Agriculture on June 26, 1906. In this circular (p. 11) paprika was defined as follows: "Paprika is the dried ripe fruit of *Capsicum annuum* L. or some other large-fruited species of Capsicum, excluding seeds and stems." This limited the applicability of the term to its narrowest sense and excluded from the definition all except the more expensive, relatively nonpungent grades. The pods when ground with the seed came under the definition of red pepper, given in the same circular (p. 11) as follows: "Red pepper is the red, dried ripe fruit of any species of Capsicum."

Later, however, this condition of affairs seems to have been somewhat modified, since in reply to a note of inquiry from the Chief of the Bureau of Plant Industry concerning the status of American-grown paprika Dr. H. W. Wiley, as chairman of the Board of Food and Drug Inspection, on November 25, 1908, said:

> The Board of Food and Drug Inspection has considered the letter addressed to it by you, under date of November 12, concerning the marketing of paprika grown in this country. The board is of the opinion that the department will take no action in the case of paprika made by grinding whole pods—that is, the shells and seeds exclusive of the stem—when the product is sold under the name of "paprika," but the paprika thus ground should not consist of a larger amount of seeds than are normal to the pods with which the seeds are ground.

In view of the fact that the seeds of paprika have a nutty, oily flavor which influences the condimental quality of the product, this practical extension of the definition of paprika made it possible for consumers to secure under the name of paprika a greater variety of condiment than before.

Since paprika has heretofore been exclusively an imported product, the question arose as to whether in a legal sense the name had acquired any geographical significance likely to interfere with the use of the name "paprika" for the American product. In answer to an inquiry on this point, Dr. Wiley, as Chief of the Bureau of Chemistry, on March 8, 1907, wrote:

> In my opinion the word "paprika" has no geographical significance and may be applied to the pepper in question, no matter where grown. I can see no objection, therefore, to its use upon pepper which has been grown from the Hungarian seed in the United States.

The two opinions quoted seem to establish the legal status of American-grown paprika.

BOTANICAL ORIGIN OF PAPRIKA.

The form of pepper chiefly concerned in this paper is one of the many forms of the almost universally distributed *Capsicum annuum* L. (Fig. 1.) In field cultures it exhibits more or less variation, but the most frequent and most desirable form corresponds to the following description:

Plants about 2 feet high, obpyramidal in form. Stems dichotomously branched, angled, subsulcate, glabrous except for slight pubescence on the angles and at the nodes, longitudinally striate with green and whitish green. Leaves ovate, acute, tapering at the base to a petiole about half as long as the blade, glabrous on both sides, dark green above, lighter beneath. Flowers solitary in the dichotomies, flowering successively from the lowest upward, throughout the season. Fruits on nodding peduncles, typically 3½ to 4 inches long, 1 to 1⅛ inches broad at the truncate base, the shoulder of which extends beyond the persistent calyx, tapering gradually to the acute, obtusish, or minutely retuse apex; surface smooth, slightly marked by longitudinal depressions, which indicate the position of the two (or more) parietal placentæ. Placentæ, meeting in the axis in the basal third of the fruit and at the extreme apex, not in contact elsewhere. Seeds compressed, broadly oval to suborbicular.

FIG. 1.—A paprika pepper plant in bearing. Height, about 20 inches.

It is probable that this type is of mixed origin, since a small proportion of shorter, more rounded, and inflated fruits occur, showing three or four rounded protuberances at the end of the pods. Occasionally a fruit occurs having almost the "bullnose" form. (Fig. 2.)

CHARACTERISTICS OF AMERICAN PAPRIKA.

The word "paprika," as it has entered into commercial use in the United States, refers to a variety of products. It is probable that the name was originally applied to the Hungarian type to which the

pepper discussed in this bulletin belongs. This type of pepper has the thick-walled, deep-red conical pod, yielding, when ground either with or without the seeds, a bright-red powder possessing to a considerable degree the characteristic pungency of most capsicums and an additional aromatic flavor much desired by its users. This pepper is much sweeter than the cayenne type and is used more freely.

The second type of paprika is derived from a rounded fruit also having a thick, deep-red "shell," but is almost devoid of pungency and seems to have a less aromatic quality. This type of pepper is

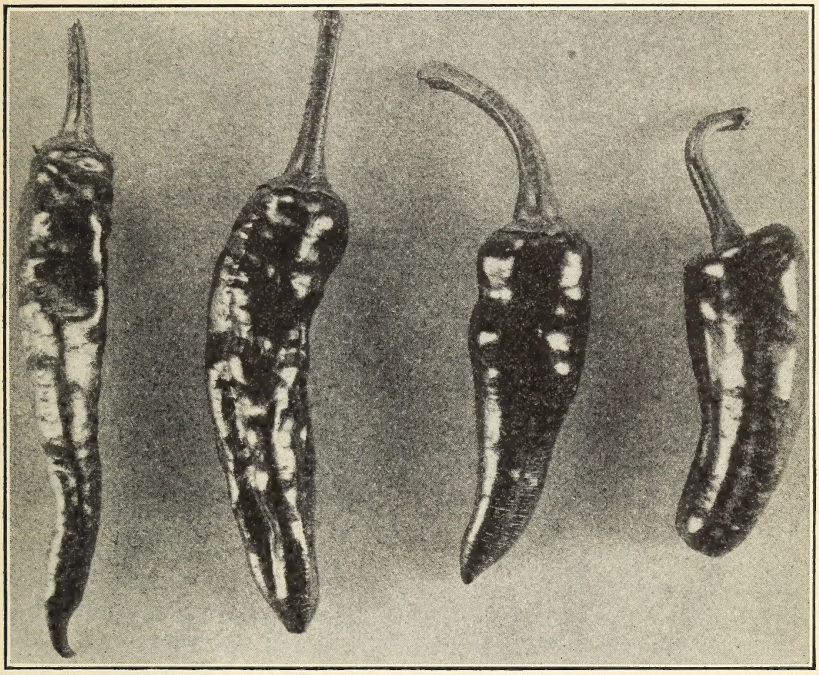

FIG. 2. —Range of form of fruits of American-grown paprika pepper, not dried. (Two-thirds natural size.)

very sweet and, owing to its high color and mildness, is used very freely, even to the point of giving a deep color to the soup, catchup, or other food product in which it is used. This latter type is known to the American trade as Spanish paprika, less often as "pimiento" or "pimenton." The paprika dealt with in this bulletin belongs to the Hungarian type, having been developed from seed obtained from the paprika district of Hungary. (Fig. 3.)

The quality of paprika pepper is largely dependent upon the following characteristics: Color, pungency, sweetness, and flavor.

COLOR.

The color desired in paprika is a bright red, not too pale and not too brownish in tinge. As the red coloring matter is found in the outer wall of the fruit, this part ("shell") when ground separately gives the lightest red color. Since, however, the shells when so ground give a dry powder which tends to fly about when used, some prefer the pods ground with the seeds. The seeds contain a large amount of a fatty oil, in which the red coloring matter is soluble, and this oil gives a slight stickiness to the powder, making it less dusty in use, brightening and deepening the color, and also aiding in bringing out its aromatic properties. The seeds, with the seed coats and other tissues present, introduce into the powder a pale brownish tinge, which to a considerable extent modifies the action of the oil present in brightening the color of the powder.

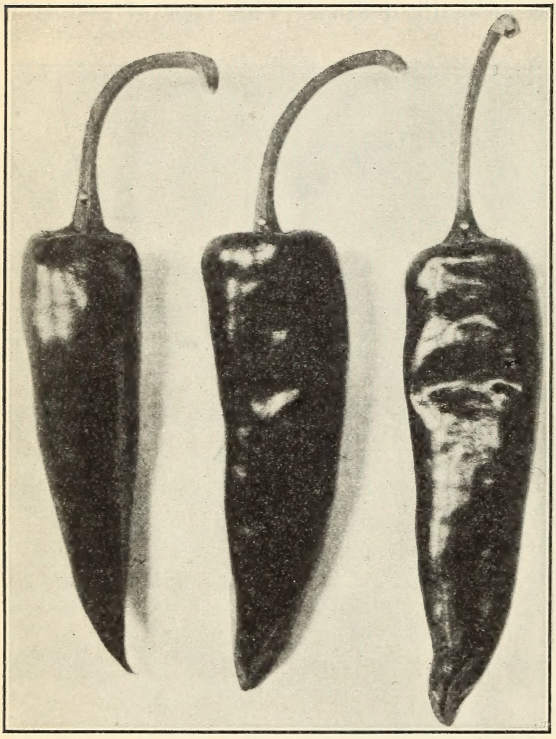

FIG. 3.—Dried American paprika peppers of desirable type. (Two-thirds natural size.)

The color is influenced to a considerable degree by the fineness of the powder. In general, the finer the powder the brighter and lighter the color.

PUNGENCY.

The degree of pungency present is an important characteristic of paprika. To those accustomed to the very mild Spanish paprika the Hungarian article is rather strongly pungent. This quality has been found by chemists to be due to a crystalline substance of somewhat doubtful chemical character, known as capsaicin ($C_9H_{14}O_2$). This substance occurs in the papery pale-reddish or yellowish tissues of the placentæ. The seeds, which are attached in a crowded ar-

rangement to the placentæ, when thoroughly dried are readily broken loose from their points of attachment and often carry with them small bits of placentæ, thereby acquiring a pungent taste.

In some cases it is probable that the loose seeds in rattling about in the shell rub against the placentæ sufficiently to get from them considerable pungency. In general, all parts of this pepper, exclusive of the placentæ, are nonpungent but may acquire pungency through contact with the placental structures. From what has been said it is clear that the sharpness of the powdered paprika is to a considerable degree dependent upon the material used in grinding. In making the milder grades of Hungarian paprika the seeds and placentæ are largely removed before the shells are ground. The pungency will vary largely in proportion to the thoroughness exercised in removing the placentæ. Pepper fruits ground whole give the maximum sharpness.

Since the pungency of the product exerts a great influence in determining the commercial value of red peppers, it was thought necessary to determine by some approximately accurate method the pungency of the American-grown product in comparison with the pungency of that of Hungarian origin. It appears to be a common practice in some commercial houses to estimate this factor by means of the sense of taste.

Mr. E. W. Durkee, of New York, pointed out the fact that in order to get a basis for commercial comparison sugars and other soluble materials are frequently made use of in measured quantities to dilute the pungent material in question. This method was adapted to the present purpose in the following manner: A small weighed quantity of the paprika powder was placed in a mortar with a small weighed quantity of cane sugar and triturated until the powders were completely mixed and reduced to great fineness. If on tasting a small portion of the powder the sensation of pungency was noted, further weighed quantities of sugar were added until the pungency could no longer be perceived. Thus a ratio was obtained between the original weight of pepper used and the weight of the sugar needed to bring the sensation of pungency just to the point of disappearance. A slight error is introduced in removing small quantities for tasting, but these amounts are so small that it is believed that the ratio obtained is not perceptibly affected. It was found that by practice it was possible to reduce tastings to a relatively small number, since both speed and accuracy were developed by painstaking effort. As would be expected, the personal equation entered to influence the result. The work was checked up by several members of the laboratory force with an almost astonishing unanimity of result. One man, a habitual smoker, was the only exception, his results showing far less sensitiveness to pungency than was found in his colleagues.

The disturbance to the sense organs involved in making the test can be reduced by making a series of triturates of known content covering the range within which the samples may be expected to fall, and begin by tasting the most dilute members of the series first. In this way the shock of the stronger reactions produced by the more concentrated triturates is avoided and the sensitiveness of the nerves conserved.

After the method had been practiced until a satisfactory degree of uniformity of result had been obtained, a standard of comparison for the American-grown peppers was sought in a series of authentic Hungarian samples representing a wide range of market sorts. The results are presented in Table I. The names of the samples are given as they appeared on the original labels. The ratio of the weight of pepper to the weight of cane sugar required to just obliterate the sensation of pungency is given in the second column, the color impression being noted in the third column.

TABLE I.—*Pungency tests with imported samples of paprika from Hungary.*

Label on sample.	Ratio of pepper to sugar.	Color.
Hof paprika Süss	1 : 300	Excellent.
Halbsüss	1 : 500	Do.
Specialität	1 : 600	Good.
Extrafein Royal	1 : 1,000	Do.
Rosen paprika	1 : 1,360	Do.
Pick Mark-Gulyos	1 : 300	Excellent.
Pick Mark-Feledes	1 : 300	Do.
Pick Mark-Paprikakul Excelsior	1 : 400	Poor.

It was thought desirable to determine the same point for commercial imported Hungarian material found in the American market. Table II shows the result of the test in seven samples obtained from six dealers in several cities.

TABLE II.—*Pungency tests with samples of imported paprika secured through American dealers.*

Nature of sample.	Ratio of pepper to sugar.	Color.
Powder from whole pod	1 : 950	Very good.
Do	1 : 700	Very poor.
Do	1 : 1,700	Poor.
Powder from shells	1 : 400	Very good.
Powder from shells of Hungarian sweet peppers	1 : 300	Do.
Powder from shells, Hungarian	1 : 1,200	Poor.
Powder from shells	1 : 400	Excellent.

A comparison of samples of home production grown at Ebenezer, S. C., was made. An average powder was obtained by grinding representative pods from many plants. It was thought desirable not only to test the powders obtained by grinding the whole pods and the

shells, but also by introducing tests on seeds and placentæ to ascertain something concerning the distribution of the pungency in the fruit. Table III presents results obtained on American-grown material.

TABLE III.—*Pungency tests with American-grown paprika.*

No.	Nature of sample.	Drying heat.	Ratio of pepper to sugar.	Color.
1	Shells without placentæ or seed	135° F.	1: 500	Very good.
2	Powder from whole pod	135° F.	1: 1,050	Good.
3	Placentæ only	135° F.	1:19,000	Poor.
4	Seed only	135° F.	1: 700	Do.
5	Shells with very few seeds	Air dried.	1: 1,200	Very good.
6	.....do	98° F.	1: 1,000	Do.
7	.....do	113° F.	1: 900	Fairly good.
8	.....do	131° F.	1: 800	Do.
9	.....do	145° F.	1: 800	Do.
10	.....do	176° F.	1: 700	Poor.

From these tables it will be seen that the home-grown product is in general somewhat more pungent than the imported article representing like structures. There are, however, imported samples of shells more pungent than the average of the home-grown samples, and imported samples of the whole pods of which the same might be said.

An examination of the results obtained by testing different parts of the fruit shows the relatively low pungency possessed by the seeds and walls in comparison with the extreme pungency characteristic of the placental tissue.

In connection with the discussion in a later part of this paper of the methods of curing ripe pods of the paprika, the temperature to be used in drying the fruit is mentioned. In working out this point of practice, pods dried at different temperatures were subjected to the pungency test in order to ascertain whether heat modifies this characteristic. The results are seen in Nos. 5 to 10, inclusive. Pods air dried were probably not submitted to a temperature of 100° F. It will be noted that as the temperature of the curing house was run higher the color of the product was impaired to a corresponding degree and the pungency correspondingly reduced. To what this latter effect is due can not be stated. That it is hardly due to the escape of the pungent constituent is shown by the fact that the atmosphere of the curing house containing tons of drying peppers is not noticeably peppery, as would be the case if capsaicin were escaping even in a small degree.

SWEETNESS.

Paprika pepper is characteristically a sweet pepper, the sugar being found chiefly in the wall of the pod. Determinations made on ground material from South Carolina pods artifically dried showed

15 per cent of glucose and 1.2 per cent of cane sugar in the dried whole pods. The dried shells showed 24.6 per cent of glucose and 1.7 per cent of cane sugar. Sun-dried pods grown at Pierce, Tex., showed a very different result, the glucose falling to 2.5 per cent and the cane sugar rising to 5.9 per cent.

FLAVOR.

The flavor of paprikas of this type, considered apart from the pungency, is an important property of the fruit, but one which can hardly be defined or measured. Apparently infinitesimal quantities of aromatic substances are effective in giving flavor, as is shown by the fact that in sugar triturations made so dilute as to lose all recognizable pungency the characteristic flavor of the fruit is still present. Dealers in paprika do not lay like emphasis on the aroma of the paprika.

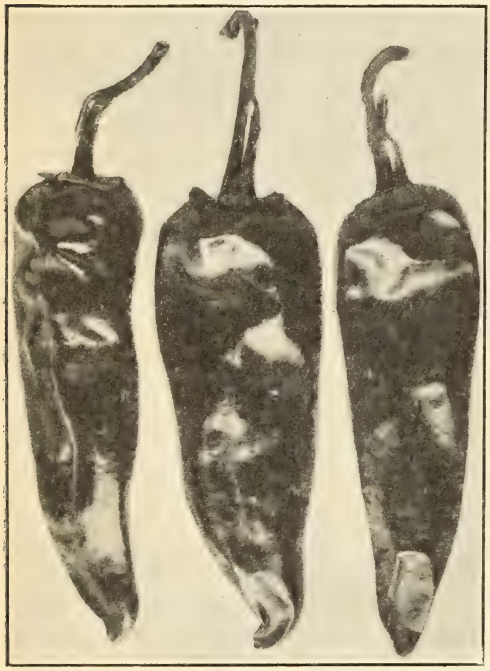

FIG. 4.—Dried paprika pepper pods grown in Hungary. Received through the Bureau of Chemistry from the Royal Hungarian Ministry of Agriculture. (Two-thirds natural size.)

WOOD FIBER.

The amount of woody fiber present is made a feature in determining standards for certain red-pepper products. Samples from South Carolina submitted to the Bureau of Chemistry for test gave for ground whole pods 20.9 per cent, for the ground shells 17.2 per cent, and for the ground shells and seed 20.4 per cent of wood fiber.

The paprika pepper fruit as collected in Hungary and sent to the United States consists of the dried fruits, with the stems which bore them. These stems, usually bent to accommodate the drooping fruits, are slender, two-sixteenths to three-sixteenths of an inch in diameter, and are usually pierced for stringing into longer or shorter festoons. (Fig. 4.) The average weight of such a dried pod was found to be about 3.5 grams, consisting by weight of about 55 to 58 per cent of shells, 29 to 33 per cent of seeds, about 8 per cent of stems, and about 4 per cent of removable placentæ.

Similar data, based on 5 pounds of dry South Carolina paprika, showed almost the same results: Shells, 60 per cent; seeds, 30 per cent; and stems, 9 per cent.

COMMERCIAL CONSIDERATIONS.

The use of paprika in the United States seems to have come with the advent of Hungarians and other European peoples accustomed to making use of it at home. According to those in touch with the development of the paprika trade, little was heard of this article until about 25 years ago, when a small local city trade in Hungarian paprika sprang up, chiefly in New York. The local demand spread gradually for some years, but during the last decade the appreciation of this condiment seems to have progressed more rapidly and to have involved classes of population other than those originally concerned. The former demand for the rather pungent Hungarian paprika seems to have been overshadowed by the much greater call for the sweeter, deeper-colored, milder Spanish paprika. Thus it has come about that the present paprika importation is overwhelmingly in favor of the Spanish type. Different dealers in touch with the paprika trade estimate that for 1 pound of Hungarian paprika, 3, 12, or even 20 pounds of Spanish paprika are imported. Owing to the lack of official statistics on these points it is impossible to verify these estimates, but it is doubtless true that at present the milder Spanish paprika enjoys a much wider popularity than the more pungent Hungarian paprika.

The dearth of official data just referred to makes it impossible to estimate with the desired accuracy the volume of the present paprika trade. About two years ago the writers interviewed a number of the chief dealers in paprika of all kinds, and after collecting and comparing the statistics obtained it seemed probable at that time that about 4,000,000 pounds of paprika were imported annually, of which amount about 3,500,000 pounds were from Spain and about 500,000 pounds were the Hungarian products.

The price of paprika, as quoted in American trade publications, deals with the ground article, a fact not to be lost sight of in comparing prices of paprika products. In fact, practically the entire importation of paprika consists of the powdered condiment. The chief reason for this is perhaps to be found in the cheap-power facilities available in Hungary and in Austria for grinding the pods.[1] Floating mills, anchored in the streams passing through the paprika-growing regions, provide facilities for milling the pods with the minimum expense.

The prices of Hungarian paprika are not obtainable from authentic official statistics, but must be sought in the current commercial

[1] Augustin, Béla. Op. cit.

literature. The files of the Oil, Paint, and Drug Reporter show that Hungarian paprika during the past two and a half years, during which this article has been given separate mention in these price lists, has been a rather steady item. The quotations rose in the latter half of the year 1910 from 16½ to 18 cents as a minimum to 25 cents as a maximum price. During 1911 the price seems to have been practically stationary at 18 to 25 cents throughout the year. In 1912 a further advance was made to a range between 20, 30, and even 34 cents per pound late in the year. High prices have continued to prevail during 1913, although November quotations show a range between 27 and 32 cents.

In this connection, it is to be noted that the product of the Department of Agriculture's experimental work was disposed of not in a ground condition but as whole pods, chiefly without the stems. The prices obtained for first-grade pods, as will be seen in consulting the details of the experiment (p. 22), have varied during the above period between 8.2 and 10.4 cents per pound, dry weight, on the cars at the point of production.

Transportation considerations enter as an important factor into the growing of paprika on a commercial basis. The purchaser prefers to have the pods in as nearly a whole condition as possible, since in whole pods no question can arise concerning the introduction into the shipment of pepper seed in excess of the natural proportions. This point assumes much importance in connection with the ruling of the Board of Food and Drug Inspection concerning the use of the name "paprika," referred to in the discussion of the legal considerations bearing on the paprika problem (p. 3). On account of this requirement it is important to prevent crushing; also, in order to secure the benefits of the better appearance presented by the whole pods, it is necessary to pack the light pods rather loosely. This makes a shipment very bulky and materially affects the cost of transportation.

CULTURAL CONSIDERATIONS.

The paprika pepper is a herbaceous annual plant which in this country fruits until checked by frost. In view of this fact the length of the crop season is an important factor in determining the yield. The experiments on which this bulletin is based were carried out at Ebenezer, Florence County, S. C., about 7 miles from Florence, and the results here reported are applicable in detail only to conditions of soil and climate similar to those found in that general region. It is believed, however, that the chief features here demonstrated can be readily adapted to other localities where the conditions are not too dissimilar.

CLIMATIC CONDITIONS.

The seat of these experiments is in the lower pine belt of the rather level Coastal Plain region. Weather observations for the neighborhood concerned are lacking, but conditions observed at Trial, Berkeley County, S. C., are believed to closely approximate those at Ebenezer and are here cited. Observations for about 17 years show an average crop-growing season (between spring and fall frosts) ranging from 230 to 240 days. The average date of the last killing frost in the spring is near March 25, and the first killing frost in autumn is about November 10. The latest killing spring frost observed occurred on April 20 and the earliest killing frost about October 20. The summer temperature rarely reaches 100° F., the summer mean being 78°. The winter minimum reaches zero, the winter mean being 48°. The mean annual rainfall is about 50 inches, the precipitation of the winter, spring, and fall averaging about 10 inches each and that of the summer approaching 20 inches. The rain falls at frequent intervals, as is shown by the fact that precipitation of 0.01 inch or more was observed on 102 days of the year.

Under the conditions described the paprika plants enjoy a long growing season with ample and well-distributed rainfall. The plants are in active fruiting condition until the early half of November, and even after that the rather heavy stems contain sufficient material to ripen the larger of the uncolored fruits. In excessively rainy periods the flowers sometimes fail to set fruit, and when such intervals occur during the latter part of the summer the fruit develops an unusual amount of disease and the ripe pods are a little off color. Sunshine is very desirable during the growing season, as it adds brilliancy to the color and assists in bringing about a uniform ripening of the fruit.

SOIL CONDITIONS.

The prevailing soil used in this work is a rather coarse sandy loam used formerly for growing tobacco and other crops. Corn, cotton, and cowpeas are standard crops for this type of soil. Favorable results on other soils, however, justify the statement that paprika peppers grow successfully on a wide variety of soil types, provided sufficient fertility is present. They thrive best, however, on a good, mellow, warm soil of either the clay-loam or sand-loam type. The soil should be well drained and still be able to retain a good supply of water.

PROPAGATION.

Paprika pepper is propagated exclusively from seed, which may be planted in a seed bed and later transplanted to the field, or the seeds may be planted directly in the field should climatic and soil conditions permit.

PREPARATION OF SEED BED.

Should it seem desirable to take full advantage of the summer season, time is gained by using a seed bed. (Fig. 5.) The area of seed bed required for 20 acres of peppers is about 200 square yards. During the experiments in South Carolina various types of seed beds have been used. However, the arrangement herein described has proved the most successful and, while somewhat more expensive than other forms tested, is of the greatest value to the grower. It is constructed as follows: An excavation 6 feet wide and 102 yards long is made, having a depth of 12 inches. On the edge of this excavation, at intervals of 10 feet around the entire bed, upright posts are erected. On the inside of these posts and in contact with the wall of the excavation are nailed boards 12 inches wide and 1 inch thick. The posts on the side to the rear are sawed off 2 feet above the level of the earth, and those on the front side 1 foot above. Therefore, three boards are required for the rear side and two for the front, one board being necessary to bring the weatherboarding to a level with the top of the ground. The ends are weatherboarded with the same material. Slats 3 inches wide and 6 feet long are nailed across at intervals of about 3 feet. In the center of each of these strips and running parallel to the edges a strip 1 inch square is nailed. Two of these strips support the glass frame in position. The frames are 3 by 6 feet.

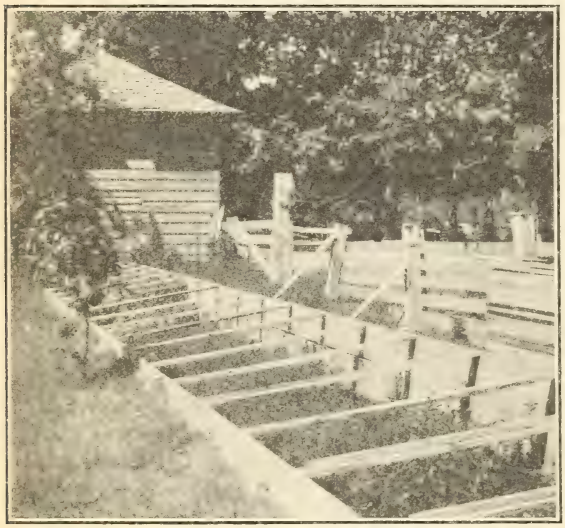

FIG. 5.—A cold frame in which pepper plants are grown.

After the framework is constructed and before it is put on, a layer of stable manure about 4 inches in depth is put in. On top of this about 4 inches of dirt is added. This is well leveled down and the seed sown and raked in with a garden rake. The bed is then covered with the glass frames. A force pump with hose connection may be brought near enough to the bed to make applications of water as often as needed. The seed is planted about the middle of March, though a month earlier would be preferable. Within about three weeks the plants are up. During the period of growth a very light

application of nitrate of soda is made. The plants are very delicate and require daily attention. They are liable to "damp off" and should be given as much air as possible by removing the frames on days when the weather is pleasant. By May the plants are large enough to transplant to the field. Of course, not all the plants are ready to come off at the same time, since some are likely to be much more advanced than others. A period of about six weeks will elapse, during which time the developing plants can be pulled from the bed. This bed, although satisfactory in every way, is perhaps more expensive than some growers could afford. As a substitute for this there may be recommended a construction similar in every way, except that the boards forming the front side of the bed need not be brought more than 3 inches above the level of the ground, and on the rear side to a height of about 12 inches above the level. Instead of expensive glass frames a medium-weight canvas or tobacco cloth may be used.

In selecting a location for the plant bed the warmest possible place should be chosen, preferably a southern exposure, and the slant of the bed should be to the south.

PLANTING TO THE FIELD DIRECT.

A plant bed is not always necessary, since in the case of an early spring the seed may be planted directly in the field and receive a start sufficiently early to yield a good crop. It is well, however, to use a plant bed as a safeguard, since the main point to be sought in pepper growing is to give the crop an early start. This is necessary in order to have a longer fruit-bearing period with a consequent heavier yield. The main difficulty experienced in these experiments has been that of getting the crop started sufficiently early.

A seed drill is the best means of planting directly in the field. The seed should be drilled in the rows 3 to 4 feet apart and should not be covered more than an inch deep. With good weather conditions the seed should sprout in from two to three weeks. When the plants are from 2 to 3 inches high they should be thinned to 12 to 18 inches apart, and plants should be set in any missing places. (Fig. 6.)

This method is not so satisfactory as that of using the plant bed as a source for plants, since by the plant-bed method the plants are up a month earlier and secure the benefits of a longer growing season.

CULTIVATION.

The cultivation of paprika pepper is in almost every respect similar to that of other field crops of the vicinity. A deep preparation of the soil is essential, and frequent shallow cultivations are necessary. The crop is cultivated longer than most crops, owing to its longer

period of growth. In South Carolina, peppers grow until the killing frosts begin; therefore cultivation is continued until the harvesting of the crop is begun in July.

FERTILIZERS.

Except in very fertile soils, fertilizers should be used, for, like most crops, peppers thrive best in soils rich in organic matter. The addition of stable manure is found to be very beneficial. Very satisfactory results have also been obtained by the application of 500 to 1,000 pounds of a mixture containing two parts of cottonseed meal, two parts of acid phosphate (14 per cent), and one part of kainit. Excellent results also followed the application of about 600 pounds of a complete fertilizer containing 4 per cent of ammonia, 8 per cent

FIG. 6.—A paprika pepper field, showing the arrangement of the plants.

of phosphoric acid, and 4 per cent of potash, reinforced by 100 pounds of sodium nitrate per acre. Half of this complete fertilizer, together with the sodium nitrate, was used in two side applications to the crop, the first being made about the last of May and the second about the last of June. The best results were obtained by an application, previous to transferring the plants to the field, of 500 pounds per acre of a mixture of two parts of cottonseed meal (17 per cent ammonia), two parts of acid phosphate (14 per cent), and one part of kainit (12 per cent). In June an application was made of 500 pounds per acre of the same mixture, together with 100 pounds of 18 per cent sodium nitrate, to each side of the rows of peppers just previous to cultivation. Side applications of available fertilizers are to be recommended for this crop on account of its long period of growth.

HARVESTING.

The pods should be uniformly ripe when picked. Although they usually begin to ripen early in July, quantities sufficient to justify picking are not usually found before the middle of the month. After the ripening season sets in it is generally necessary to pick about every seven days. (Fig. 7.) By picking thus frequently the curing houses are not overloaded and the crop is conveniently handled. In Hungary the pepper fruits are picked with the stems attached, to give opportunity for stringing the fruits into long festoons, in which form they are hung up to dry. In South Carolina, where artificial

FIG. 7.—Picking paprika peppers. The pods are piled on sheets at the end of the rows.

heat is used in specially constructed houses, the stems are not needed and the fruits are picked without them.

CURING.

The processes of curing and picking peppers are closely related, in that the amount of peppers to be picked at any one time should not exceed the available drying facilities, and the curing barn must be so managed as to finish up each picking before the succeeding lot of pods requires the building. This means that a curing barn of a given capacity will serve a definite acreage of pepper field. As-

suming a usual yield of pods, a curing barn 20 feet square, with 18-foot posts and a high pitched roof, can by proper management cure the peppers grown on a 10-acre field. This assumes such features of construction as are described for increasing the floor surface of the barn.

The curing barn used in this work is a simple 4-walled building, 20 feet square, with 18-foot posts and a steeply pitched roof. (Fig. 8.) The tightly built walls rise from the ground and there is no floor. The barns are usually made with double walls in order better to retain the heat.

In one end of the building are two brick furnaces built 12 feet apart. These furnaces (figs. 9 and 10, *a*) are semicircular in shape, or archlike, and are 7 feet long, 2 feet high, and 2 feet in width. They are built on the ground with about 18 inches extending outside the barn, 5½ feet being inside (fig. 10). From the interior end of these furnaces sheet-iron flues (*b*), 10 to 12 inches in diameter, extend along the side of the house to within 2 feet of the opposite end wall. Here by means of elbows the flues are carried to a point 2 feet short of the middle line, at which place, again by means of elbows, the flues return to the first end of the barn and after making another turn pass out at a point just above the furnace. The flues throughout their course are slightly ascending, and the smoke which traverses them, with the hot air, is discharged through a pipe (*c*) above the furnace. (Figs. 9 and 10.)

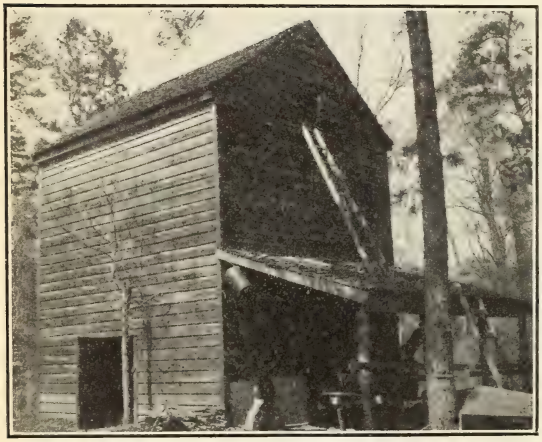

FIG. 8.—Curing barn used in drying paprika peppers.

The crates to receive the peppers during the drying process consist of wire-bottomed trays 8 feet long, 30 inches wide, and 5 inches deep. (Fig. 11.) To construct a crate, a rectangular wooden frame 8 feet long by 30 inches wide is made, using material 1 inch thick and 2 inches wide. Midway between the ends a crosspiece is nailed in order to strengthen the frame and support the wire. To this frame the wire is tacked with small staples. The best wire to use is the quarter-inch galvanized-iron kind, but if it is desirable to use a cheaper quality the 16-mesh wire gauze can be used instead, reducing the cost to about one-third the price of the stronger

wire. After the wire has been tacked on, a board 6 inches wide is nailed to the end of the four sides of the frame, thereby making a container 5 inches in depth. These wire crates are supported in the barn by timbers 2 by 4 inches nailed across from one side to the other. The crate should rest on three of these, one being at each end and one at the center. The first layer of these crates is about 6 feet above the floor of the barn. An opening 4 feet wide is left the entire width of the barn and extends to the top. On each side of this opening the crates are placed, four to each level and four tiers high. Between each two crates a space is left, and the crates on the next tier above are not placed directly over those below, but alternate with the open spaces. This gives room for 16 crates to each side, with an open space through the center of the barn. About 4 bushels of the freshly picked pods can be placed in each of these crates, making a total of 128 bushels to each curing.

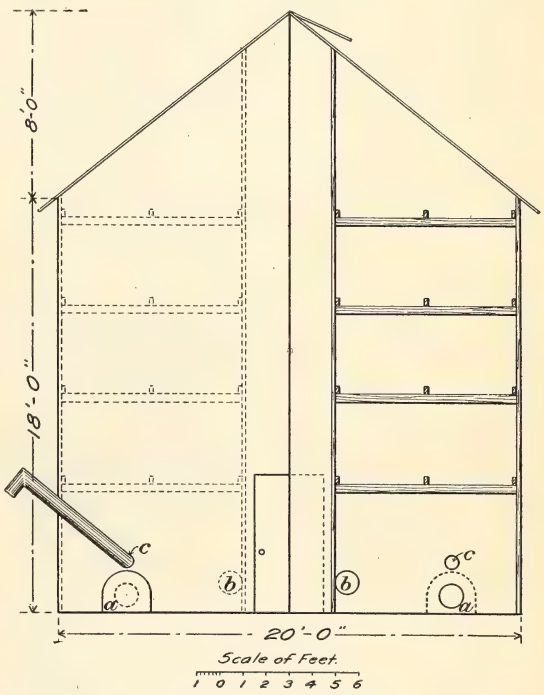

FIG. 9.—End view of a paprika curing house, showing furnaces, smoke pipes, and the arrangement of the interior framework to support the crates.

After the crates are placed in position and filled the heat may be started. This is done by building a fire in the furnaces outside. The heat is advanced directly to between 135° and 150° F. and held at that point for about 72 hours, the time required to complete the process. The peppers are then taken out and placed in containers in some good storage house until through the absorption of a slight amount of water from the air the pods become somewhat flexible.

STORAGE.

After the peppers are taken from the drying barn they should be placed in a good dry storage house and left in the containers until they become flexible. They should then be worked over, taking out all

defective pods, which may be known as "grade 2," the first-class pods, of course, being referred to as "grade 1." After assorting, the peppers are placed in bags, preferably the 5-bushel size, which hold about 50 pounds of dried pods. They are then stored away as compactly as possible until marketed. The peppers should not stand too long in storage, as they deteriorate in value. Rats also are very destructive to peppers.

YIELD.

The experimental cultivation of paprika on an acreage basis was begun in 1905, and was continued under careful observation for four seasons. During that period the effect of variation in weather conditions had an opportunity to develop. The degree of completeness of the stand was found to vary as a result of the different causes. With increasing familiarity with the practical handling of the crop, some variation in yield may have been due to the human factor. It is probable that the results reported here may therefore be taken to represent fairly well the range of paprika yields likely to be met under usual conditions, assuming a practice of careful farming.

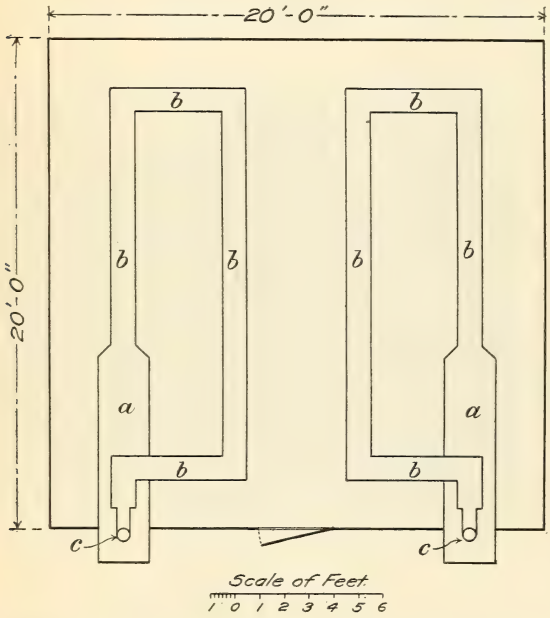

FIG. 10.—Ground-floor plan of a paprika curing barn.

In 1905 three acres of paprika were planted, the total yield which resulted being about 3,200 pounds of dried pods, the average yield per acre being about 1,067 pounds. In 1906 two plats were grown. One plat of one-half acre yielded 425 pounds, giving a rate of 850 pounds per acre. The other plat of 4 acres yielded 3,280 pounds, an average of 820 pounds per acre. In 1907 a plat three-fourths of an acre in extent yielded 1,015 pounds, or at the rate of 1,353 pounds per acre. In 1908 it was deemed justifiable to undertake the experiment on a larger basis. Plat No. 1, comprising 10 acres of ground, yielded 13,969 pounds, an average of 1,396.9 pounds per acre. Plat No. 2,

a 5-acre tract in which the seed was planted directly in the field, yielded 4,800 pounds, an average of 960 pounds per acre. Plat No. 3, occupying 3 acres, showed a very poor stand, the plants growing in the seed bed being transplanted to the field in June. As a result of late transplanting a large proportion of the plants succumbed. A yield of only 1,504 pounds was obtained, averaging 501 pounds of dried pods to the acre. The total yield of the whole year's planting of 18 acres was 20,273 pounds of dry pods, an average of about 1,126 pounds per acre. This land would have produced under ordinary circumstances about 1 bale of cotton per acre.

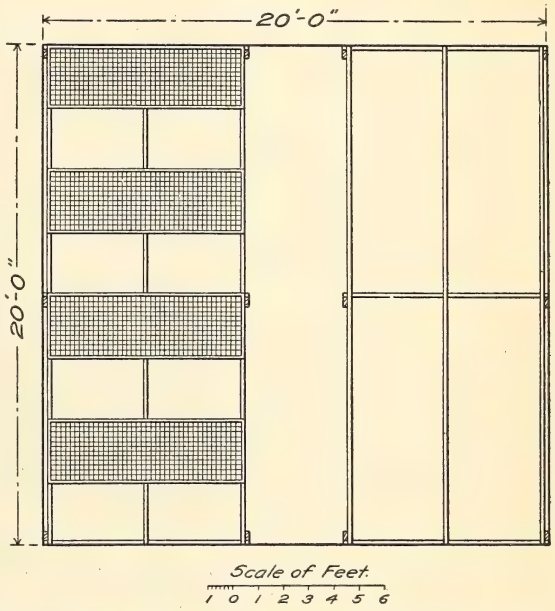

FIG. 11.—Plan of floor of a paprika curing barn, showing on the right side the arrangement of the timber supports and on the left the crates in position.

FINANCIAL RETURNS.

After a small quantity needed for laboratory work at Washington had been taken out, the peppers grown in these experiments were put on the market. Samples were taken by one or the other of the writers to the chief dealers in dried peppers and placed in direct competition with red peppers imported whole or ground for use in the American market. At first, largely on account of the novelty of the article, buyers were somewhat slow to purchase. Others were in the habit of buying peppers already powdered and did not care to buy pods. The first two crops were picked with the stems attached to the pods in imitation of the imported article. When it was found that the presence of the stems was an objectionable feature, the peppers were picked without stems, eliminating one factory process for the purchaser. This was found to help the sale of the pods, and although the weight of the crop was somewhat reduced it was deemed best to meet the manufacturers' wishes. A noticeable increase in the cost of picking was also charged to this innovation, but it appears probable that the attempt to satisfy the buyer in this particular was a most

helpful move. An additional difficulty in introducing the American-grown pepper was found in the uncertainty as to the future of the industry. Dealers felt disinclined to give up old commercial relations for new ones which might not yield the desired quantities year after year. This difficulty was met only by continuing to offer the peppers in increasing quantity until at the present time the home-grown product is finding an increasingly ready sale in the chief American markets.

The prices obtained for South Carolina paprika pods showed relatively little variation during the period covered by the experiment, but a slight tendency toward improvement was noted, due in part, perhaps, to the better quality of goods produced as the experiment progressed and in part to the general market conditions in the paprika trade.

Table IV gives a summarized statement of the chief financial features developed by the experiment.

TABLE IV.—*Financial summary of the experiment in growing paprika.*

Year.	Average yield per acre.	Average price per pound.	Average gross income per acre.	Average cost per acre.	Average profit per acre.
	Pounds.	*Cents.*			
1905	1,067	9.3	$98.78	.....	.....
1906	823	8.2	67.84	.....	.....
1907	1,353	9.3	125.13	.....	.....
1908	1,127	10.4	117.45	$29.30	$87.92
General average	1,092	9.3	102.23	31.97	70.26

A review of the items of income and expense, in large part not given here, shows that for the period covered the paprika experiment gave a profit each year, but varied widely according to the weather and other conditions which might affect the success of the operation. Under the most unfavorable conditions experienced, the profits compared well with the standard crops of the vicinity, being about $35 per acre. Under more favorable conditions the outcome was more satisfactory, the balance remaining after the expenses of growing the crop were met rising as high as $93 per acre.

It must be borne in mind that various items properly chargeable against the income were not so charged. Among items excluded are the interest on the investment, the deterioration of machinery, and the salary of the Government expert who supervised the work.

Throughout the experiment itemized expense accounts were kept, but since it is believed that the distribution of the expenses in 1908, when the largest area was handled, is fairly representative of what the paprika grower is likely to experience, data were compiled from the results of that year and grouped according to the type of process

involved, thus showing the percentage of the total expenditure demanded for these different features of the problem. The results are given in Table V.

TABLE V.—*Distribution of expenditures required in producing the paprika crop.*

Item of expense.	Percentage involved.
Preparing and sowing the seed bed	3.5
Preparing and cultivating land	9.3
Transplanting plants to field and resetting to stand	3.2
Fertilizers	32.0
Picking the pepper fruit	24.7
Handling peppers, care of fires during curing, etc	16.3
Fuel bill (pine wood)	3.7
Grading, sacking, handling, etc., including the price of sacks	7.0
Total	99.7

The cost of picking was calculated on the weight of the fresh pods picked by each individual. These pods were carefully weighed at the end of the picking, and the price paid was 20 cents per hundred pounds. This system of payment had the advantage of securing the picker's best efforts and was familiar to him through his experience in picking cotton.

The fuel item is likely to vary according to the supply available and the convenience of securing it. The other items will also show some departures from those here given, since practice, and therefore expense, will vary from year to year in the same place and between places differently situated. The labor item is a very important factor, absorbing probably half of the total expense, while of the items for materials the fertilizer bill is by far the most prominent.

OUTLOOK FOR THE FUTURE.

The outlook for the future of paprika culture in the United States should be considered with reference to the possibility of its profitable extension. It is not yet clear to what extent the spice manufacturer or dealer will be able or willing to replace the paprika now imported with the American-grown article. It is possible, and indeed probable, that the home-grown article will fail to meet the taste of many paprika users, but it is likely, on the other hand, in time to make a place for itself with others. Assuming that the American article could command the market now supplied by imported Hungarian paprika, and assuming also that the rough estimate of the annual importation of this article is approximately correct at 500,000 pounds, with an average production of 1,000 pounds of dried paprika pods per acre, an area of 500 acres of paprika would supply the demand. It is probable, however, that owing to the marked pungency of the powdered pepper made by grinding the whole pod and the very

handsome color of the product, a considerable use of these pods under the label of "red pepper" is likely to add largely to the sale of this product in the spice market. Time alone can tell to what extent American pepper may eventually be used. This uncertainty, taken in connection with the very evident fact that the market can be easily oversupplied if considerable areas of paprika are planted, indicates that the growing of paprika of the type here described can be easily overdone.

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